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ABSTRACT

This eighth in a series of ten modules for a course titled Welding Inspection describes controls necessary to place the proper electrode or rod at each welding station. More specifically, the module describes use of the American Welding Society specifications, control of weld filler material after receipt from the supplier, and methods of ensuring proper application of the filler material. The module follows a typical format that includes the following sections: (1) introduction, (2) module prerequisites, (3) objectives, (4) notes to instructor/student, (5) subject matter, (6) materials needed, (7) procedures, (8) data table, (9) reference materials, (10) test. (The course is one of fifteen technical courses for the second year of a two-year postsecondary curriculum in Nuclear Quality Assurance/Quality Control Technology.) (LRA)

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NUCLEAR TECHNOLOGY

COURSE 28 WELDING INSPECTION

MODULE 28-8 Filler Metal Control

CE 024 268

GENERAL PHYSICS CORPORATION
Columbia , Maryland

COURSE MODULES

COURSE 28 WELDING INSPECTION

Module 28-1	Welding Fundamentals and Processes
Module 28-2	Shielded Metal Arc and Oxyacetylene Welding
Module 28-3	Tungsten Inert Gas (TIG), Metal Inert Gas (MIG) and Submerged Arc Welding
Module 28-4	Weld Joint Verification
Module 28-5	Qualifications
Module 28-6	Process Controls
Module 28-7	Acceptance Inspection
Module 28-8	Filler Metal Control
Module 28-9	Weld Repair Control
Module 28-10	Records

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This module was prepared by General Physics Corporation by John Espy of General Physics.

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INTRODUCTION

There are many different welding electrodes and rods which visually appear to be identical. The differences involve the specific chemistry of the metal and the ingredients of coverings and fluxes. Since each unique electrode or rod is designed for specific applications, controls are necessary to place the proper electrode or rod at each welding station. This module describes controls for accomplishing this function.

The American Welding Society has standardized the classification of electrodes and rods through the publication of specifications which govern the quality of each type of filler material. Welding codes applicable to nuclear power plants require use of these specifications for the procurement of weld filler materials. In this manner, a product of known quality is the starting point for control of weld filler material. This module describes use of the AWS specifications, control of weld filler material after receipt from the supplier, and methods of ensuring proper application of the filler material.

The Nuclear QA/QC Technician is typically responsible for assisting in the development of the procedures and practices employed for control of weld filler material. Once the procedures are in place, the QA/QC Technician is responsible for monitoring work practices for compliance with established controls.

MODULE PREREQUISITES

All previous modules in Course 28 must be completed before proceeding to this one. Also Course 15, entitled Metallargy and Metals Properties is very useful for proper understanding of this module.

OBJECTIVES

Upon completion of this module, the student/trainee shall be able to:

1. Name two methods for selecting the proper filler materials for purchase and use.
2. State the purpose of filler material specifications.
3. Define the terms classification, identification, and grouping as related to filler materials.
4. Describe the correlation of classification numbers to requirements of filler material specifications. Describe why such correlation is useful.
5. Describe the identification marking requirements for filler materials.
6. State the purpose of filler material group numbers assigned by the ASME Boiler and Pressure Vessel Code.
7. Name the five essential elements of filler material control, define each, and describe the role of each with regard to controlling filler material.
8. Describe the difference between a Certificate of Compliance and a Certified Material Test Report.
9. Describe the role of a user's control number and compare it with the role of a supplier's heat or lot number.

SUBJECT MATTER

SELECTION AND PURCHASING OF FILLER MATERIAL

Earlier modules of this course have pointed out that welding filler materials must be compatible with the base material. That is, the resultant weld metal chemistry and mechanical properties must be similar to those of the base metal such that the weld will meet its design requirements. The engineering activity within a company normally determines the specific welding filler material to be purchased and used.

Codes governing design of nuclear components and structures give criteria for the selection of filler material. Basically, these codes ensure selection of proper filler material for use by either of two means:

- The code specifies the exact filler material to be used for welding specific base material.
- The code requires qualification of the filler material to be used.

In either case, the codes require manufacture of filler materials to standards to provide a common and known product quality for consideration in welding applications. These standards are developed by the American Welding Society (AWS) in the form of specifications which govern the quality of filler materials. Most of the AWS specifications are adopted for use in nuclear power plant applications by the American Society of Mechanical Engineers (ASME).

For welding applications governed by the ASME Boiler and Pressure Vessel Code, Section III of the Code requires use of filler material described by Section II of the Code. Section II gives applicable specifications for filler materials. These specifications are identical to AWS specifications which are required by AWS Structural Welding Code and AWS Reinforcing Steel Welding Code. Table 28-8-1 lists

Table 28-8-1

Filler Material Specifications

ASME No.	AWS No.	Title
SFA 5.1	A5.1	Mild Steel Covered Arc-Welding Electrodes
SFA 5.2	A5.2	Iron and Steel Gas Welding Rods
N/A	A5.3	Aluminum and Aluminum-Alloy Arc-Welding Electrodes
SFA 5.4	A5.4	Corrosion-Resisting and Chromium and Chromium-Nickel Steel Covered Electrodes
SFA 5.5	A5.5	Low Allow Steel Covered Arc-Welding Electrodes
SFA 5.6	A5.6	Copper and Copper Alloy Covered Electrodes
SFA 5.7	A5.7	Copper and Copper Alloy Bare Welding Rods and Electrodes
SFA 5.8	A5.8	Brazing Filler Metal
SFA 5.9	A5.9	Corrosion-Resisting Chromium and Chromium-Nickel Steel Bare and Composite Metal Cored and Standard Arc-Welding Electrodes and Rods
SFA 5.10	A5.10	Aluminum and Aluminum Alloy Welding Rods and Bare Electrodes
SFA 5.11	A5.11	Nickel and Nickel-Alloy Covered Welding Electrodes
N/A	A5.12	Tungsten-Arc Welding Electrodes
SFA 5.13	A5.13	Surfacing Welding Rods and Electrodes
SFA 5.14	A5.14	Nickel and Nickel-Alloy Bare Welding Rods and Electrodes
N/A	A5.15	Welding Rods and Covered Electrodes for Welding Cast Iron
SFA 5.16	A5.16	Titanium and Titanium-Alloy Bare Welding Rods and Electrodes
SFA 5.17	A5.17	Bare Carbon Steel Electrodes and Fluxes for Submerged Arc Welding

Table 28-8-1

Filler Material Specifications (Continued)

ASME No.	AWS No.	Title
SFA 5.18	A5.18	Mild Steel Electrodes for Gas Metal-Arc Welding
N/A	A5.19	Magnesium Alloy Welding Rods and Bare Electrodes
SFA 5.20	A5.20	Mild Steel Electrodes for Flux-Cored Arc Welding
N/A	A5.21	Composite Surfacing Welding Rods and Electrodes
SFA 5.22	A5.22	Flux Cored Corrosion-Resisting Chromium and Chromium-Nickel Steel Electrodes
SFA 5.23	A5.23	Bare Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding
SFA 5.24	A5.24	Zirconium and Zirconium Alloy Bare Welding Rods and Electrodes
SFA 5.25	A5.25	Consumables Used for Electroslag Welding of Carbon and High Strength Low Alloy Steels
SFA 5.26	A5.26	Consumables Used for Electrogas Welding of Carbon and High Strength Low Allow Steels

the AWS filler material specifications and corresponding ASME Boiler and Pressure Vessel Code identification. The purchase order for filler materials invokes the applicable specification for the specific filler material ordered.

FILLER MATERIAL CLASSIFICATION, MARKING, AND GROUPING

Definitions

The terms classification, marking and grouping have special significance to the control of filler materials. These terms are identified as follows:

- Classification is the assignment of unique alpha-numeric identifiers which are correlated by the filler material specification with specified values to be met by the filler material. Any given electrode has one, and only one, classification.
- Marking is the identification of filler material classification and lot or heat number.
- Grouping is the assimulation of classifications which are considered "like-type" for qualification purposes.

Classification Schemes

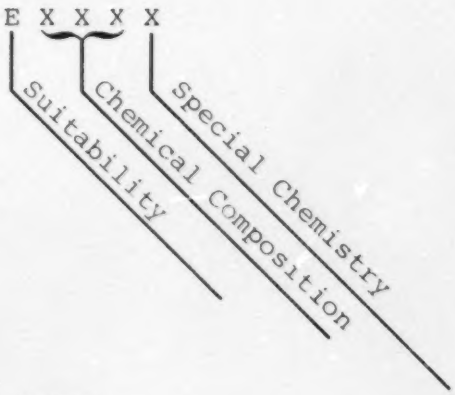
Each of the twenty-six filler material specifications listed in Table 28-8-1 gives the classification scheme for electrodes and/or rods manufactured to the specification. Within each specification, tables are given which identify the classification alpha-numeric number and the corresponding values to be met by the electrode or rod or the weld made by the electrode. Such values include requirements for chemistry, mechanical properties, coating, and flux, as applicable to the specific filler material. Since any given rod or electrode has one and only one classification, the classification defines the chemical and physical properties of the rod or electrode. Therefore, knowledge of the classification permits locating within the specification those chemical and mechanical properties which are met by the filler material.

All of the classification schemes employ "E" to signify electrode and "R" to signify rod. Electrodes are suitable as current carrying consumable electrodes. Rods are suitable as non-current carrying filler material which must be consumed by a separate flame or arc. Bare filler material which is suitable as an electrode and a rod is designated "ER".

While descriptions of all the classification schemes are too voluminous for this module, classifications for several commonly used filler materials are described.

Low alloy steel and stainless steel covered electrodes are widely used in shielded metal arc welding process. Classification of such electrodes purchased to SFA 5.4 and SFA 5.5 are illustrated as follows:

Stainless Steel Covered Electrodes, SFA 5.4, Classification



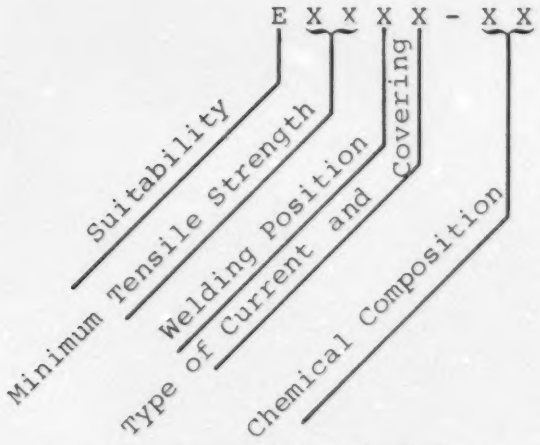
Example: E308L, Where:

E = Electrode

308 = Chemical Composition as Specified in Table 2 of SFA 5.4

L = Special Chemical Composition as Specified in Table 2 of SFA 5.4 (Low Carbon)

- Low Allow Steel Covered Electrode, SFA 5.5, Classification



Example: E 7010 - Al Where:

E = Electrode

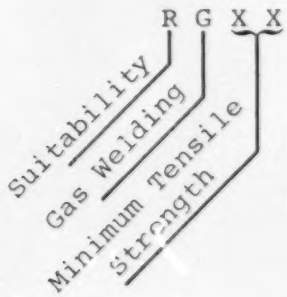
70 = 70,000 psi Minimum Tensile Strength of the Weld Deposite (Note: Units are Always in Thousands of psi. When Minimum Tensile Strength is 100,000 psi or More, a Five Digit Number is Used with the First Three Digits Representing Minimum Tensile Strength, e.g., E11018 - D2).

1 = All Welding Positions (Note: Either 1 or 2 is Used. When the Electrode is Suibtable for all Positions, it is Assigned a 1. When its Suitability is Limited to Flat and Horizontal, it is Assigned a 2).

0 = The Type of Covering and Current as Listed in Table 1 of SFA 5.5.

Al = The Chemical Composition of the Weld Deposit as Listed in Table 2 of SFA 5.5.

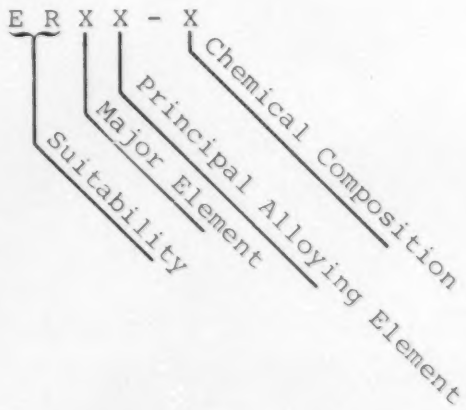
Specification SFA 5.2 describes requirements for rods used in oxyacetylene welding of carbon and low alloy steels. Classification of these "gas" rods are as follows:



Example: RG60, Where:

R = Rod
G = Gas Welding
60 = 60,000 psi Minimum Tensile Strength

Metal inert gas and tungsten inert gas welding of nickel-base alloys with solid bare electrodes use the electrodes governed by SFA 5.14. The classification of such spooled electrodes are as follows:



Example: ERNi-1

ER = Electrode and Rod

Ni - Nickel (No Principal Alloying Element)

1 - Chemical Composition per Table 1 of SFA 5.14

Example: ERNi Cr Fe - 5

ER = Electrode and Rod

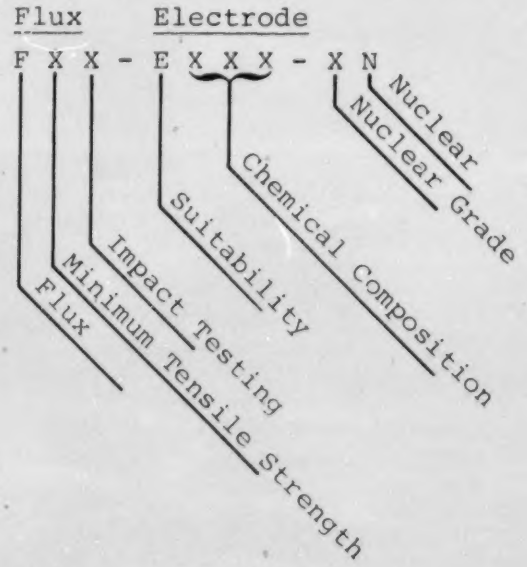
Ni = Nickel

Cr = Chromium (First Principal Alloying Element)

Fe = Iron (Second Principal Alloying Element)

5 - Chemical Composition as Specified in Table 1 of SFA 5.14

Filler materials for submerged arc welding of carbon and low alloy steels are governed by SFA 5.17. This specification classifies the flux - electrode combination as follows:



Example: F62 - EM12 - 1N, Where:

F = Flux

6 = 60,000 psi Minimum Tensile Strength of Weld Metal Deposited with this Flux-Electrode Combination

2 = Deposited Weld Metal Must Meet Impact Testing Requirements at - 20°F (Possible Other Codes are Z - No Impact Test Required, 4 - Impact Testing at - 40°F, and 6 - Impact Testing at - 60°F)

E = Electrode

M12 = Chemical Composition of the Electrode as Given by Table 1 of SFA 5.17

1 = Class 1

N = Nuclear Restriction Apply (the N is Applied for Electrodes Used in Making Welds Which Will be Exposed to Radiation. When it is Applied, the Restrictions Given by SFA 5.17 on Sulphur, Phosphorus, Copper and Vanadium Contents Must be Met. Such Elements Lower the Resistance to Material Damage by Radiation)

Marking

Each filler material specification requires specific marking and labeling which serve to identify the filler material. Such requirements apply to marking of packages and in certain instances, marking of filler material.

- Marking of Packages, Spools and Drums - Covered electrodes, straight length bare rods and electrodes, coils and electrodes, and fluxes are placed in

"packages" to prepare them for shipment from the filler material supplier's plant. Such packages are typically cylindrical cans for covered electrodes, rectangular boxes for straight length bare rods, and square boxes for coils and fluxes. Continuous length bare electrode is wound on spools or drums. The packages for covered electrode, straight length bare rod electrode, coils and fluxes and the hub of spools and drums are marked as follows:

a. Classification Number
b. Filler Material Specification Number
c. Supplier's Name, Trade Designation, and Lot or Heat Number
d. Net Weight
e. Size of rods or electrodes

- Marking of Electrodes and Rods - In addition to marking of packages, spools and drums, marking is also required for covered electrodes and sometimes required for straight length electrodes and rods. All covered electrodes are marked with the classification number on the covering close to the grip end of the electrode. Where specified, straight length bare electrodes and rods are marked in either of two ways. Larger diameter straight lengths (typically 1/8 inch and larger) are marked with the classification number. Smaller diameter straight lengths are marked with a dot of color to represent the classification number. A description of the color-to-classification code employed must accompany the shipment. Also, purchasers may agree to accept "flag tag" marking of straight lengths. Flag tags are narrow adhesive strips which are marked with the classification number and are attached to one end of the rod or electrode.

Grouping

As described in Module 28-5, the type of filler material is an essential variable of a welding procedure specification. A change in the type of filler material requires requalification of the welding procedure specification. What constitutes a "type" of filler material requires definition to permit uniform application of the requalification requirments.

The AWS Structural Welding Code and Reinforcing Steel Welding Code do not group filler materials. Instead, each code stipulates those specific changes in filler material classification which require requalification. Such changes typically involve an increase in tensile strength (e.g., change from E7018 to E8018), a change in electrode diameter (does not involve classification), and a change from one filler material specification to another, (e.g., change from E70S of AWS 5.18 to E70T of AWS 5.20). Therefore, the practical grouping of filler material of these codes is first by filler material specification number and secondly by specific requirements applicable to each welding process.

The ASME Boiler and Pressure Vessel Code groups filler materials by classification number. Each group of filler materials contains such similar properties as to permit qualification of any one of the group to constitute qualification for all of the group within certain limits. Such limits involve specific changes for specific welding processes which are significant to the welding process. For example, a change from bare solid electrode to flux cored electrode for metal inert gas welding requires requalification although these two filler materials are within the same group. Except for such special, defined instances, the group number governs the requalification requirements.

The ASME Boiler and Pressure Vessel Code groups filler material by "F" numbers and "A" numbers. The "F" numbers represent those classifications of similar properties. The "A" numbers represent chemical analysis of weld deposits. The code stipulates requalification in terms of F numbers and A numbers, i.e., a change in F number or a change in A number requires requalification. Tables 28-8-2 and 28-8-3 list the F and A groupings.

ESSENTIAL ELEMENTS OF CONTROL

Each company who uses filler material is faced with establishing controls which place the proper, acceptable filler materials at each welding operation at the time it is needed for use. Since most companies who perform welding employ several welding processes and weld several types and grades of material, a number of filler material classifications must be controlled.

Control of filler materials employs the essential elements of certification, identification, segregation, traceability, and environmental protection. These essential elements are applied to each step in the handling and use of filler materials as illustrated in Figure 28-8-1.

Certification

Certification is defined as the act of attesting to the quality of the filler material. Certification always involves a statement signed by an official of the supplier which attests that the filler material supplied conforms with the applicable specification requirements. Such statements are termed Certificate of Compliance.

Table 28-8-2

F Grouping

F No.	ASME Specification No.	AWS Classification No.
	Steel and Steel Alloys	
1	SFA 5.1 & 5.5	EXX 20, EXX 24, EXX 27, EXX 28
2	SFA 5.1 & 5.5	EXX 12, EXX 13, EXX 14
3	SFA 5.1 & 5.5	EXX 10, EXX 11
4	SFA 5.1 & 5.5	EXX 15, EXX 16, EXX 18
4	SFA 5.4 Nom. Total Alloy 6% or less	EXX 15, EXX 16
4	SFA 5.4 Nom. Total Alloy more than 6%	EXX 15, EXX 16
5	SFA 5.4 Cr-Ni Electrode	EXX 15, EXX 16
6	SFA 5.2	RGXX
6	SFA 5.17	FXX-XXXX
6	SFA 5.9	ERXX
6	SFA 5.18	EXXS-X, EXXU-X
6	SFA 5.20	EXXT-X
6	SFA 5.22	EXXXT-X
6	SFA 5.23	FXX-EXXX-X, FXX-ECXXX-X, and FXX-EXXX-XN, FXX-ECXXX-XN
	Aluminum and Aluminum-Base Alloys	
21	SFA 5.10	ER 1100, ER 1260
22	SFA 5.10	ER 5554, ER 5356, ER 5556, ER 5183, ER 5654
23	SFA 5.10	ER 4043
24	SFA 5.10	R-SC 51A, R-SG 70A
	Copper and Copper-Base Alloys	
31	SFA 5.6 & 5.7	RCu, ECu
32	SFA 5.6 & 5.7	RCuSi-A, ECuSi
33	SFA 5.6 & 5.7	RCuSn-A, ECuSn-A, ECuSn-C
34	SFA 5.6 & 5.7	RCuNi, ECuNi
35	SFA 5.6 & 5.7	RBCuZn-A, RCuZn-C
36	SFA 5.6 & 5.7	ER-CuAl-A1, ER-CuAl-A2, E CuAl-A2, ER-Cu-Al-A3, E-CuAl-B
37	SFA 5.6 & 5.7	E-CuNiAl, E CuMnNiAl, ERCuNiAl, ERCuMnNiA
	Nickel and Nickel-Base Alloys	
41	SFA 5.11	E Ni-1
41	SFA 5.14	E Ni-1
42	SFA 5.11	E NiCu-7
42	SFA 5.14	ER NiCu-7
43	SFA 5.11	E NiCrFe-1
43	SFA 5.11	E NiCrFe-2
43	SFA 5.11	E NiCrFe-3
43	SFA 5.11	E NiCrFe-4
43	SFA 5.11	E NiCrMo-2
43	SFA 5.11	E NiCrMo-3
43	SFA 5.14	ER NiCr-3
43	SFA 5.14	ER NiCrFe-5
43	SFA 5.14	ER NiCrFe-6
43	SFA 5.14	ER NiCrMo-2
43	SFA 5.14	ER NiCrMo-3
44	SFA 5.11	E NiMo-1
44	SFA 5.11	E NiCrMo-4
44	SFA 5.11	E NiCrMo-5
44	SFA 5.14	ER NiMo-1
44	SFA 5.14	ER NiMo-2
44	SFA 5.14	ER NiMo-7 (Alloy B-2)
44	SFA 5.14	ER NiCrMo-4
44	SFA 5.14	ER NiCrMo-5
44	SFA 5.14	ER NiCrMo-7 (Alloy C-4)
45	SFA 5.11	E NiCrMo-1
45	SFA 5.14	ER NiCrMo-1
45	SFA 5.14	ER NiFeCr-1
	Unalloyed Titanium	
51	SFA 5.16	ERTi-1, ERTi-2, ERTi-3, ERTi-4
	Zirconium and Zirconium Alloy	
61	SFA 5.24	ER Zr1 ER Zr2 ER Zr3

Table 28-8-3

A Grouping

QW	A No.	Types of Weld Deposit	Analysis* C %	Cr %	Mo %	Ni %	Mn %	Si %
442	1	Mild Steel	0.15				1.60	1.00
	2	Carbon-Moly	0.15	0.50	0.40–0.65		1.60	1.00
	3	Chrome (0.4 to 2%)–Moly	0.15	0.40–2.00	0.40–0.65		1.60	1.00
	4	Chrome (2 to 6%)–Moly	0.15	2.00–6.00	0.40–1.50		1.60	2.00
	5	Chrome (6 to 10.5)–Moly	0.15	6.00–10.50	0.40–1.50		1.20	2.00
	6	Chrome-Martensitic	0.15	11.00–15.00	0.70		2.00	1.00
	7	Chrome-Ferritic	0.15	11.00–30.00	1.00		1.00	3.00
	8	Chromium-Nickel	0.15	14.50–30.00	4.00	7.50–15.00	2.50	1.00
	9	Chromium-Nickel	0.30	25.00–30.00	4.00	15.00–37.00	2.50	1.00
	10	Nickel to 4%	0.15		0.55	0.80–4.00	1.70	1.00
	11	Manganese-Moly	0.17		0.25–0.75	0.85	1.25–2.25	1.00
	12	Nickel-Chrome-Moly	0.15	1.50	0.25–0.80	1.25–2.80	0.75–2.25	1.00

*Single values shown above are maximum.

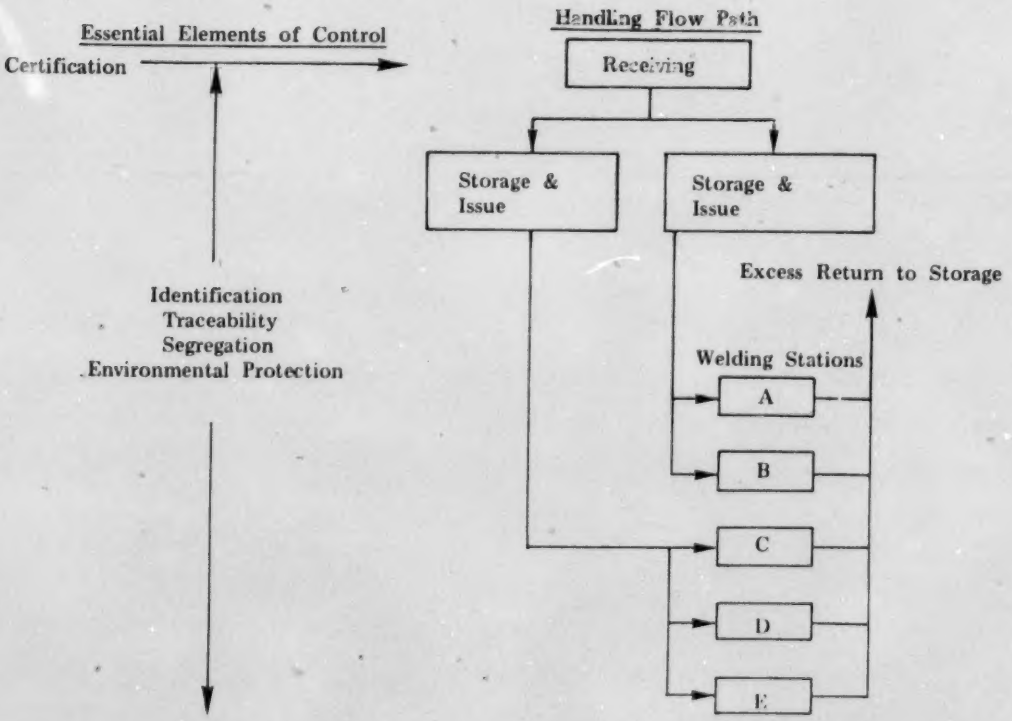


Figure 28-8-1 Application of Essential Elements to Filler Material Flow Paths

In addition to Certificate of Compliance, actual results of acceptance testing performed by the supplier may be required as part of the certification. The ASME Boiler and Pressure Vessel Code requires reporting of actual test results. The AWS Structural Welding Code and AWS Reinforcing Steel Welding Code charge the design engineering activity with specifying those specific instances where actual test results must be reported. In any event, reporting of actual test results is via a Certified Material Test Report.

Certified Material Test Reports identify the results of acceptance testing required by the purchase order and by the filler material specification. These tests require the consumption of rods and electrodes and, therefore, are performed with sample rods and electrodes selected from a population having essentially identical quality. The population is defined as a lot for covered electrode and flux-cored electrode and a heat for bare rod and electrode. Lots and heats are defined as follows:

- Lot of Covered Electrodes or Flux-Cored Electrodes is defined as the quantity of electrodes produced from the same combination of heat of metal and dry batch or dry blend of flux where:
  - ____ dry batch is defined as the quantity of dry ingredients mixed at one time in one mixing vessel
  - ____ dry blend is defined as one or more dry batches mixed in a mixing vessel and combined proportionately to produce a uniformity of mixed ingredients equal to that obtained by mixing the same total amount of dry ingredient at one time in one mixing vessel

- Lot of Submerged Arc Flux is defined as the quantity of flux produced from the same combination of raw materials under one production schedule.
- Heat of Bare Electrode, Rod or Consumable Insert is defined as the material produced from the same melt of metal.

Where required, Certified Material Test Reports are provided for each lot or heat. These reports identify the results of acceptance testing illustrated in Table 28-8-4.

Table 28-8-4

Acceptance Testing

Type of Electrode or Rod	Tests (Note 1)	Purpose of Tests
Covered Electrode	Chemistry Radiography Tensile Impact (Note 2)	Composition of Weld Soundness of Weld Strength of Weld Ductility of Weld
Straight Length Bare Rod and Electrode	Chemistry Visual (Note 2)	Composition of Rod or Electrode Soundness of Weld
Spooled Bare Electrode	Chemistry Cast and Helix Radiography (Note 2) Tensile (Note 2) Impact (Note 2) Bend (Note 2)	Composition of Electrode Electrode Freedom from Kinks and Internal Stresses Soundness of Weld Strength of Weld Ductility of Weld Ductility and Soundness of Weld

NOTES: 1. Tests are performed on either the rod/electrode or a weld made by the rod/electrode as specified.
2. These tests are required for certain classifications only.

Identification

Identification is defined as the act of (a) confirming the existence of marking and certification and (b) applying a control number. It is accomplished within the receiving inspection activity.

Confirming the existence of marking and certification is a direct function of receiving inspection. The receiving inspector compares the purchase order and material specification requirements with the marking and certification of the filler materials to conform that specified requirements have been met by the supplier.

At this point, it is important to note that the quality of weld filler materials is based on the requirements of the material specification. A logical question is whether each lot of heat of a given classification are suitable for specific applications. When considering specific applications, several variables affect the suitability of the filler material. For example, the preheat and interpass temperature limits and post weld heat treatment affect the performance of the filler material. For this reason, the ASME Boiler and Pressure Vessel Code requires specific additional tests of filler material for certain applications. Since there is some variation between lots or heats of filler material, each lot or heat must be tested. For welding applications involving AWS Structural Welding Code and AWS Reinforcing Steel Welding Code, tests in addition to those of the filler material specification are not required unless specifically requested by the design agency.

The additional tests required by the ASME Boiler and Pressure Code are summarized below. These tests are applicable for specific types of welds as identified by the Code.

- Tensile and Impact Tests - Where required, a weld metal test plate is made with each lot or heat of

electrode or rod and with each welding process which will use the filler material. The weld metal test plate is subjected to the same post weld heat treatments that apply to production welds and then sectioned for testing. Such tests determine that each heat or lot will produce the strength and ductility required by the design for the specific application.

- Chemistry Tests - Where required, the chemistry of the weld metal is determined. Since the filler material specification often requires identical testing, the user may require the supplier to perform this test and report the results in the Certified Material Test Report. However, because the Code sometimes requires use of the shielding which will be used in production welding, the user must either stipulate the welding parameters to the supplier or perform this test internally. The test determines that the electrode/rod and shielding combination provides acceptable weld metal chemistry.
- Delta Ferrite Tests - Where required, weld metal deposits are analyzed for ferrite content. The user normally requires the supplier to perform this test and include the results in the Certified Material Test Report. The test is required for certain austenitic stainless steel applications where a definite amount of ferrite is described to improve resistance to cracking.

Use of a control number permits distinguishing specific lots and heats of filler material. As indicated by the foregoing discussion on additional test requirements, two lots of the same classification may be suitable for use as received or may require further testing. The specific welding application determines whether additional testing is required. Most companies establish engineering instruc-

tions to their metallurgy department for performing such additional testing and for assigning control numbers to each heat and lot of filler material. In this manner, a control number represents a known quality of the filler material. This quality represents that required by the welding code versus that required by the filler material specification.

The control number is added to the marking of packages, spools and drums when the filler material has been accepted by the additional tests or when it is known that no further testing is required. Also, the control number is placed on each test report including the supplier's certification. The filler material is now ready for storage and issue as the need arises. A listing which correlates each welding procedure specification with the control numbers of all lots or heats of filler material acceptable for use with each welding procedure specification permits issue of proper filler material to welding stations.

Segregation

Segregation is defined as the physical separation of filler materials by control number. It maintains identification of each individual package, spool or drum of filler material. Segregation prohibits comingling of filler material with different control numbers regardless of classification number. Thus, segregation guards against the inadvertant use of incorrect material. It is accomplished by procedures and work practices which include the following for all handling steps:

- Maintaining filler material in the as-supplied packages, spools, and drums wherever possible. Such containers bear the supplier's markings and the user's control number.

- Where filler material is removed from its container, providing another container marked with the correct control number.
- Requiring excess filler material to be returned from welding stations to storage in its marked container.
- Requiring scrapping of filler material for which identification has been lost.

Traceability

Traceability is defined as the ability to determine the quality of any filler material before or after its use.

Traceability is accomplished by use of the control number. At any time prior to using filler material, the practices for identification and segregation ensure that the filler material is identified by its control number at all times. At the point of use, the control number is either specified by the welding instructions or it is recorded on the weld joint record. From the control number, the corresponding metallurgical test reports and Certified Material Test Report can be retrieved.

Environmental Protection

Environmental protection is required to maintain cleanliness of filler material and, for covered electrodes and submerged arc welding fluxes, to prevent excess absorption of moisture. Either lack of cleanliness or moisture can cause weld defects.

Suppliers of filler material provide the materials in a state of cleanliness as required by the filler material specification. Regardless of the type of filler material, the supplier places it in sealed packages or bags which maintain its cleanliness.

The user of filler material maintains cleanliness by keeping the materials packaged until it is to be used at a welding station. Proper work practices by the welder ensures that cleanliness is maintained. For example, the welder does not place the filler material where it would contact excessive dirt, oil, grease, or other loose surface materials. Except for spools and drums of bare electrode which are mounted on welding machines, the filler material is consumed or returned to storage before a concern with cleanliness might arise. As long as welding machines are consuming spools or drums of bare electrode, there is no probable concern for cleanliness. However, if the machine is idle for one or more shifts, considerable dirt can collect on the exposed electrode. In such cases, dust covers are placed over the spool or drum.

Prevention of excessive moisture absorption is a more difficult matter. As long as covered electrodes and fluxes remained sealed in the supplier's packages, moisture absorption is minimal. When the seal is broken, however, moisture absorption begins at a slow rate which is dependent on temperature, humidity, and type of covering or flux. Control is established by placing the covered electrodes or fluxes in an environment which retards moisture absorption and drives out excess moisture. That is, covered electrodes and fluxes are heated prior to use.

Practical application of moisture control demands that a supply of dry electrodes and fluxes be available in quantities needed by the welders. Therefore, each storage and issue point normally has holding ovens stocked with a day's supply of covered electrodes and fluxes. The ovens are maintained at a temperature of 200^{o}F an 300^{o}F. Covered electrodes and fluxes are issued from these ovens to the welding stations.

In most instances, use of the covered electrodes or fluxes within 8 hours of issue from the holding ovens ensures that insufficient moisture is absorbed to be of concern. Where electrodes or fluxes remain at a welding station for use on consecutive shifts or where it is suspected that excessive moisture is causing or may cause weld defects, portable ovens are provided to the welders for keeping the materials heated.

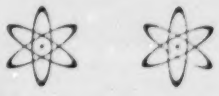
In the event covered electrodes or flux has been unsealed and unheated for an indeterminate time, heating them to 600°F for a few hours ensures adequate drying. If covered electrodes or fluxes are directly exposed to water, they should be scrapped.

EXERCISES

The following exercises serve to reinforce the concepts presented in this module.

1. Discuss how to determine what filler material to select for a given weld.
2. The use of a particular filler material type may cause additional test requirements for a given weld. Discuss how one may determine the additional testing requirements needed.
3. How are specific chemical and mechanical requirements for filler material specified?
4. Explain why filler materials are grouped according to "like-type" filler materials.

5. List the information which must be marked by the supplier on packages, spools and drums of filler material.
6. Briefly discuss the five essential elements for the control of filler materials.
7. Briefly explain the purpose of a Certified Material Test Report regarding material specification.
8. In reference to filler materials compare and contrast the following two terms:
   a. Classification identity
   b. Control number identity
9. Explain why it is important to physically separate filler materials according to control numbers.
10. Traceability is accomplished through application of the control number to packages, spools or drums and to each piece of paperwork relating to the corresponding heat or lot of filler material. Explain why this is important.
11. Why is environmental protection of welding rods and electrodes necessary.
12. Visit a job site where welding is being performed. Using Table 28-8-5, Control of Weld Filler Materials given in the Data Table along with the corresponding Procedure given in this module, prepare a report on the control of weld filler material using the Procedures and Data Table as a guide.



MATERIALS

None.

PROCEDURES

In reference to Exercise #12, it is suggested that the students/trainees visit a job site where welding is taking place and control of weld filler material is being carried out. Carry out the following procedure:

1. Obtain permission to visit the site.
2. Obtain any protective clothing required (hard hats, safety goggles etc.)
3. With the assistance of the job foreman or his/her designee, trace the events which occur in the receipt and use of either a lot of covered electrode filler material or a lot of spooled electrode.
4. Prepare a report on your tour which includes a description of the receipt of either of these two types of electrodes and proceed with the handling of them until their consumption in a weld.
5. In order to aid you in your report, review the Data Table (Table 28-8-5, Control of Weld Filler Materials) which gives a description which starts with receipt of these two types of electrodes and proceeds with the handling of them until their consumption in a weld. The description gives specific values for each element which are typical of those found at the job site. It is assumed that electrodes meet all inspection and test requirements.

DATA TABLE

The application of essential elements for the control of weld filler materials is described on the following pages by indicating the events which occur in the receipt and use

Table 28-8-5

Control of Weld Filler Materials

Event	Applicable To	
	Covered Electrode	Spooled Electrode
1. Receipt Inspector Confirms:		
a. Marking of Sealed Can Agrees with Purchase Order and Material Specifications: E9018-B3L, SFA 5.5, ABC Welding Products, Inc., Lowcarb 90, Lot D182, 5/32", 10 lbs.	X	
b. Spool in Sealed Plastic; Marking on Hub Agrees with Purchase Order and Material Specification: SFA 5.14, ERNiCrFe-5, Nimend, 0.035", 25 lbs., Heat 78-135		X
c. Certified Material Test Report Values Agree with Purchase Order and Material Specification Requirements	X	X
d. Receipt Inspection Paperwork Forwarded to Metallurgy Lab Who Determines:		
(1) The covered electrode requires additional testing for use in the ASME Code applications. With the assistance of engineering, weld lab, and QC, sample electrodes are withdrawn, a weld test plate is made and properly heat treated and subjected to tensile and impact tests. Afterwards, control number H-1166 is marked on all the paperwork which is filed. A release form is issued to receiving inspection which identifies E9018-B3L, Lot D182 as having control number H-1166.	X	
(2) The spooled electrode requires chemistry and delta ferrite testing of a weld deposit made with production welding procedures to be suitable for ASME Code application. The purchase order stipulated these tests including the welding parameters to be used. Results are contained in the Certified Material Test Report. Control number H-1167 is marked on all paperwork which is filed. A release form is issued to receiving inspection which identifies ERNiCrFe-5, Heat 78-135 as having control number H-1167.		X

Table 28-8-5

Control of Weld Filler Materials (Continued)

Event	Applicable To	
	Covered Electrode	Spooled Electrode
e. Receipt Inspection Marks Each of the 50 Cans of E9018-B3L, Lot D182, with the Control Number H-1166 and Each of the 25 Spools of ERNiCrFe-5, Heat 78-135 with the Control Number H-1167	X	X
f. Receipt Inspection Releases the Material to Storage	X	X
2. Storage and Issue		
a. Attendant Stores 46 Cans E9018-B3L, Lot D182, Electrodes Together on a Shelf and Opens and Places Four Cans in the Holding Oven on a Shelf Marked H-1166 (NOTE: One Can Would Have Been Opened Previously for the Additional Tests) Attendent Stores 25 Spools of ERNiCrFe-5, Heat 78-135, Together on Shelves and in Their Plastic Bags and Shipping Boxes	X	X
b. Daily, the Attendant Opens 4 Cans of E9018-B3L, Lot D182 and Places Them in the Holding Oven	X	
c. Daily, Request Forms for Filler Material are Received by Stores Which Identify the Welding Procedure Specification, the Control Number Desired and the Signature of the Welding Foreman. Requests are Honored if the Listing Issued by Metallurgy Lab Assigns the Requested Control Number to the Welding Procedure Specifications. The Attendent Notes on the Form the Weight of Electrode Issued	X	X
d. Daily, Surplus Materials are Returned. The Attendant Confirms the Materials are in Their Marked Can or Spool and Places Covered Electrodes in the Holding Oven and Spooled Electrode on Shelves	X	X
3. Welding Operations		
a. Daily, the Welding Foreman Selects "Job Packages" for Welding Schedules for that Day. The Foreman Confirms existence of Welding Procedure Specification, Fit-Up Instructions, and Inspection Instructions. The Foreman Prepares a Filler Material Request Form by Extracting the Classification and Size (e.g., E9018-B3L, 5/32")	X	X

Table 28-8-5

Control of Weld Filler Materials (Continued)

Event	Applicable To	
	Covered Electrode	Spooled Electrode
from the welding procedure specification and selecting the appropriate control number from the listing published by the Metallurgy Lab. Upon receipt of the filler material, the "job" is assigned to a welder.		
b. A QA/QC Technician is monitoring welding operations and observes SMA welding with H-1166. The technician observes that: (1) a properly executed filler material request form is in the job package. (2) electrode classification and size agree with the welding procedure specification. (3) three cans of E9018-B3L are at the station; each is marked Lot D182, H-1166. Two of the cans are in a portable warming oven and the other is next to the welder. These later electrodes are warm to the touch. (4) no other filler materials are at the welding station.	X	
c. The same QA/QC Technician then monitors MIG welding stations and observes an idle machine which has spooled electrode loaded in the machine. The technician observes that: (1) a dust cover is over the spool. (2) upon removing the dust cover, the marking on the hub bears H-1167, SFA 5.14, ERNiCrFe-5, 0.035, 25 lbs., Heat 78-135. (3) the welding foreman possesses a job package completed that shift which required use of H-1167 and contains a properly executed filler material request form. The foreman has another job package requiring use of H-1167. The foreman states that the next shift will commence the second job. (4) no other filler material is at the welding station.		X
d. The same QA/QC Technician reviews the qualification records of the welding procedure specifications which were included in the job packages for SMA and	X	X

Table 28-8-5

Control of Weld Filler Materials (Continued)

Event	Applicable To	
	Covered Electrode	Spooled Electrode
MIG welding. The SMA procedure was qualified using E9015-B3L electrode. Since the F and A numbers are the same for this electrode for E9018-B3L, the procedure is qualified. The MIG procedure was qualified using ERNiCrFe-5 electrode.		
4. Post Operations Phase In the twentieth year of operation, inservice inspection detects a small crack in a weld. A portion of the investigation of probable cause is charged with determining which filler material was used. Review of records for the cracked weld joint reveals that H-1166 (or H-1167) was used. Further review finds that this filler material was properly tested, accepted, and used. This source of potential cause is eliminated.	X (either)	X (either)

of a lot of covered electrode and a heat of spooled bare electrode.

The description starts with receipt of these two types of electrodes and proceeds with the handling of them until their consumption in a weld. The description gives specific values for each element which are typical of those found at the job site. It is assumed that electrodes meet all inspection and test requirements.

This Data Table is intended for use in carrying out Exercise #12.

REFERENCE MATERIALS

American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, Section II, III and IV, New York, New York

American Welding Society, Structural Welding Code D1.1 and Reinforcing Steel Welding Code D12.1, New York, New York

TEST

1. List the two methods for selecting the proper filler materials for a given job.

2. State the purpose(s) for filler material specifications.

3. Define the following terms in reference to filler materials:
   a. Classification
   b. Identification
   c. Grouping.

4. Classification is the assignment of unique alpha-numeric identifiers which correlate with specific chemical and mechanical requirements of the filler material specification. Purchase orders should identify both the classification and material specification numbers. Each material specification describes its scheme for classifying rods and electrodes covered by the specification. Briefly discuss why this is useful.

5. Which of the following are essential elements for the proper control of filler materials?
   a. Certification
   b. Identification
   c. Quality
   d. Segregation
   e. Traceability
   f. Environmental protection
   g. All of the above

6. Describe the difference between a certificate of Compliance and a Certified Material Test Report.

7. Briefly describe the role of a user's control number and compare it with the role of a supplier's heat or lot number.